DESCRIPTION

ELECTROSTATIC SPRAYING DEVICE

TECHNICAL FIELD

The present invention relates to an electrostatic spraying device for personal use, and more particularly to a device for spraying a liquid composition by means of an electrostatic force.

BACKGROUND OF THE INVENTION

WO 03/072263 discloses an electrostatic spraying device having a removable cartridge containing a volume of a liquid composition. The device includes a plunger pump that displaces the liquid out of the reservoir and a nozzle for dispensing the liquid. The nozzle is provided with an emitter electrode which applies a high voltage to the liquid composition being supplied from the reservoir to the nozzle, i.e., electrostatically charge the particles of the liquid composition for spraying the composition on a user's skin by the electrostatic force. In order to start spraying the electrostatically charged liquid composition, the user is required to feed the liquid composition to the nozzle to drip it out of the nozzle and subsequently, after confirming the dripping, to apply the high voltage to the liquid composition being supplied to the nozzle. This is because, if the liquid composition has not yet advanced to the emitter electrode, electrostatical spraying is not likely to start immediately. Thus, the absence of the confirmation might give uncertainty to the user whether or not the device operates normally. However, the confirmation requires the user to take extra steps of ejecting the cartridge out of its position in the main body of the device,

manually operating the cartridge to drip the liquid composition prior to energizing the pump and the emitter electrode, and returning the cartridge in position. This is cumbersome and therefore detracting from easy handling of the device. There remains a need for providing a device which enables easy dripping of the liquid composition prior to electrostatically spray.

None of the existing art provides all of the advantages and benefits of the present invention.

SUMMARY OF THE INVENTION

The present invention is directed to an electrostatic spraying device which is capable of spraying the liquid composition successfully only through a simplified step of confirming that the liquid composition is ready for being immediately sprayed electrostatically. The electrostatic spraying device in accordance with the present invention is configured and disposed to electrostatically charge and dispense the liquid composition from a supply to a point of dispense. The device includes an actuator, a high voltage generator to provide a high voltage, a power source to activate the actuator and the high voltage generator, a reservoir to contain the supply of the liquid composition, and a dispensing unit. The dispensing unit is provided to spray the liquid composition and includes a pump which is mechanically connected to the actuator to be driven thereby. An emitter electrode is included in the dispensing unit to be electrically connected to the high voltage generator in order to electrostatically charge the liquid composition. Also included in the dispensing unit is a nozzle that is disposed at the point of dispense for dispensing the liquid composition. The device further includes a switch for manipulating the power

source. One characterizing feature of the present invention resides in that a selector is included to provide a spraying mode and a dripping mode selectively in response to the switch being manipulated. The dripping mode defines a mode in which the pump is alone actuated to dispense the liquid composition out through the nozzle absent electrical charge, and the spraying mode defines another mode in which the pump as well as the emitter electrode are simultaneously activated to dispense the liquid composition out through the nozzle with the liquid composition being electrically charged prior to exiting the nozzle. Thus, the user can easily drip the liquid composition by simply manipulating the selector prior to initiating the electrostatic spraying, which assures easy handling of the device and the successful spraying.

In a preferred embodiment, a housing is provided to carry the actuator, the actuator, the high voltage generator, the power source, the switch, and the selector.

Preferably, the selector is exposed on the exterior of the housing to be manipulated by the user's finger, and is movable between a dripping position defining the dripping mode and a spraying position defining the spraying mode. The selector surrounds the switch in immediately adjacent relation thereto and rotatable about an axis between the dripping position and the spraying position. Thus, the selector and the switch can be easily manipulated by a single finger, i.e., a thumb of the user's hand grasping the housing for enhanced convenience of operating the device.

The selector may have a lock position which prohibits the motor and the emitter electrode from being activated, in order to prevent an unintended and accidental operation of the device.

It is also preferred that the housing is formed on its exterior with an indicator which indicates which one of the dripping mode and the spraying mode is selected for easy confirmation by the user.

Alternately, the selector may be of a pressure-responsive type which is actuated by the switch to give the dripping mode in response to the switch handle being pressed to a first extent, and give the spraying mode in response to the switch being pressed to a second extent greater than the first extent.

Further, the spraying mode may be arranged to start activating the pump after a short delay from activating the high voltage generator. In view of a possible delay in generating a stable voltage output from the high voltage generator, the pump is controlled to supply the liquid composition only after the emitter electrode sees the stable high voltage output. Thus, the liquid composition can be charged to an intended level as soon as it is supplied from the reservoir to the dispensing unit, thereby assuring optimum performance of electrostatically applying the liquid composition.

Still further, the spraying mode may be arranged to include monitoring of the voltage output from the high voltage generator and to cease activating the high voltage generator and the pump when the monitored voltage output exceeds a critical level as indicative of an unallowable corona discharging at the emitter electrode, thereby assuring the safe operation of the device.

These and still other features, aspects, and advantages of the present invention will become more apparent from the following detailed explanation of preferred embodiments when taken in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the invention, it is believed that the present invention will be better understood from the following description of preferred, nonlimiting embodiments and representations taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of an electrostatic spraying device in accordance with a preferred embodiment of the present invention;

FIG. 2 is a vertical section of the device of FIG. 1;

FIG. 3 is a front view of the device of FIG. 1;

FIG. 4 is a side view of the above device;

FIG. 5 is an exploded perspective view of the above device;

FIGS. 6 to 8 are respectively exploded perspective views of a removable cartridge utilized in the above device;

FIG. 9 is a perspective view of the cartridge of FIG. 8 as viewed from the bottom;

FIG. 10 is a bottom view of the cartridge of FIG. 9;

FIG. 11 is a sectional view of the dispensing unit;

FIG. 12 is a section take along line X-X of FIG. 11;

FIG. 13 is a perspective view of a main body housing of the device;

FIG. 14 is a perspective view of a metal plate forming a part of the dispensing unit;

FIG. 15 is a partial rear section showing an electrical connection between the dispensing unit and a voltage terminal provided on the side of the housing;

FIG. 16 is a partial vertical section showing the electrical connection between the dispensing unit and the voltage terminal;

FIG. 17 is an exploded perspective view of the housing of the device;

FIG. 18 is a perspective view of the device shown with a front shell of the housing removed;

FIG. 19 is an exploded perspective view illustrating a center frame of the housing, a motor and a high voltage generator mounted on the frame in accordance with the preferred embodiment of the present invention;

FIG. 20 is an exploded perspective view showing the motor and its associated parts accommodated within the housing in accordance with the preferred embodiment of the present invention;

FIG. 21 is a perspective view of the above device with the inner cover removed;

FIG. 22 is a perspective view of the above device shown with the cartridge and an inner cover removed;

FIG. 23 is a vertical section of the device corresponding to FIG. 22;

FIG. 24 is an exploded perspective view of parts forming a field electrode and associated parts of the above device;

FIG. 25 is a perspective view of the above device with an outer cover attached;

FIG. 26 is a vertical section of the above device with the outer cover attached;

FIG. 27 is a plan view of the cartridge;

FIG. 28 is a front view of a fitment attached to a reservoir of the cartridge;

FIG. 29 is a cross section taken along line X-X of FIG. 28;

FIG. 30 is an exploded perspective view illustrating a switch, a selector, and associated parts of the device;

FIGS. 31A to 31C illustrate different positions of the selector, respectively;

FIGS. 32 and 33 are block diagrams respectively illustrating the operation of a spraying mode and a dripping mode given to the device;

FIGS. 34 and 35 are block diagrams of an indicator respectively illustrating the

operation of a spraying mode and a dripping mode given to the device in accordance with a modification of the above embodiment;

FIG. 36 is a block diagram of an indicator illustrating the operation of a spraying mode and a dripping mode given to the device in accordance with a modification of the above embodiment;

FIGS. 37A to 37C illustrate different positions of a switch for making an analogous function of the selector in accordance with a preferred embodiment of the present invention; and

FIG. 38 is a block diagram illustrating the operation of the spraying mode utilized in accordance with another preferred embodiment of the present inevention..

DETAILED DESCRIPTION OF THE INVENTION

Now referring to FIGS. 1 to 7, there is shown an electrostatic spraying device in accordance with a preferred embodiment of the present invention. The device is configured into a self-contained portable structure that is compact enough to be easily carried with. The device is basically composed of a main body housing **10** and a removable cartridge **200** containing a volume of a liquid composition to be electrostatically sprayed according to a mechanism already disclosed in WO 01/12336, WO 01/12335, US 2001-0020653A, US 2001-0038047A, US 2001-0020652A, US 2001-0023902A, and WO 03/072263, incorporated herein by reference. The liquid composition utilized in the device include those disclosed in WO 03/072263, also incorporated herein by reference, i.e., an emulsion having conductive and insulating phases, although not limited thereto.

The housing **10** is dimensioned to be grasped by a user's hand and

incorporates an electric motor **30**, a high voltage generator **40**, and a battery **50**, i.e., a power source for activating the motor and the high voltage generator **40**. The motor **30** actuates a dispensing unit **220** provided on the side of the cartridge **200** to dispense the liquid composition, while the high voltage generator **40** applies a high voltage of 1000 volts or more to the liquid composition being dispensed for electrically spraying the liquid composition on a user's . The housing **10** is formed with a concavity **12** for receiving a reservoir **210** of the cartridge **200** containing the liquid composition. In a preferred embodiment, an inner cover **20** is detachably fitted over the upper end of the housing **10** to hold therebetween the dispensing unit **220** of the cartridge **200**. In another preferred embodiment, an outer cover **26** is detachably fitted over the inner cover **20** to conceal therebehind the dispensing unit **220** for protection thereof when the device is not in use.

The cartridge **200** is preferably composed of the reservoir **210** and the dispensing unit **220**. The reservoir **210** may be suitably made of a plastic material which is deformable according to the contents of the liquid composition. The reservoir 210 may be made by the same resilient material, or combination of a rigid material and resilient material. An example of commercially available material suitable for providing the reservoir is the laminated film of VM-PET (Vacuum Metalised Polyethylene Terephthalate) having a thickness of 12 microns and LLDPE (Linear Low Density Polyethylene) having a thickness of 60 microns. Commercially available films are GLAE by Toppan for VM-PET, and FCS by Tocello for LLDPE. The reservoir may also be made of conductive material and being electrically connected to the high voltage generator so that the liquid composition therein is provided with more less a common electric potential.

As best shown in FIGS. 6 to 9, in a preferred embodiment the dispensing unit **220** includes a pump **230** and a nozzle **240** which are integrated into a single structure. The pump **230** is a gear pump having a flat base **231** molded from a plastic material and formed with a plug **232** for detachable insertion into a fitment **212** secured to a mouth of the reservoir **210**. The pump **230** includes a metal plate **270** mounted in the base **231** of the molded plastic. The metal plate **270** is formed in its upper surface with a pump chamber receiving a pair of intermeshing gears **234**, an inflow channel **236** extending from within the plug **232** to the chamber, and an outflow channel **237** extending from the chamber to the nozzle **240**. The pump chamber as well as the channels **236** and **237** are sealed by an emitter electrode **250** secured between the base **231** and the nozzle **240**. The gears **234** are arranged to have their individual rotation axes extending perpendicular to the plane of the base **231**, realizing a flat pump structure sufficient to be capable of being disposed between the reservoir **210** and the nozzle **240** only at a minimum extra dimension with respect to the height or length of the dispensing unit **220**. One of the gears **234** is coupled to a joint **238** projecting on the lower face of the base **231** for detachable driving connection with the motor **30** disposed within the housing **10**. As the gears are driven to rotate, the liquid composition is sucked up from the reservoir **210** through the inflow channel **236** and expelled through the outflow channel **237** to the nozzle **240**. Preferably, the nozzle **240** is molded from a compatible plastic material as the base **231** to have an internal nozzle pathway **242** extending from the bottom center to an apex **243**, as best shown in FIG. 2.

The emitter electrode **250** is disposed between the base **231** of the pump **230** and the bottom **241** of the nozzle **240** in order to apply the high voltage to

and charge the liquid composition being dispensed through the nozzle **240**. In a preferred embodiment, the emitter electrode **250**, which is connected to receive the high voltage from the high voltage generator **40** in the housing **10**, includes a center antenna **251** and a coaxial cylinder **252**. The center antenna **251** extends into the nozzle pathway **242** to charge the liquid composition being dispensed in cooperation with the cylinder **252** that is provided to surround the nozzle pathway **242** to avoid the undesired corona discharging for suitable electrostatic spraying. The top end of the center antenna **251** is receded from the apex **243** of the nozzle **240** to give a sufficient insulation distance therebetween.

As best shown in FIGS. 13 to 16, the metal plate **270** is formed integrally with a pin **254** which projects through the base **231** for detachable electrical connection with a voltage terminal **176** provided on the side of the housing **10** to relay the high voltage to the emitter electrode **250**. Turning back to FIGS. 6 and 7, the emitter electrode **250** also includes a flat bottom **253** that is placed over the base **231** to seal the pump. The flat bottom **253** and the metal plate **270** are cooperative to charge the liquid composition within the pump in order to avoid undesired current flow within the liquid composition in the pump which would otherwise cause deterioration of the liquid composition. As shown in FIGS. 11 and 12, the cylinder **252** is connected to the antenna **251** by a rim **255**. The rim **255** is formed with a plurality of slots **256** that communicate with the outflow channel **237** of the pump for passing the liquid composition from the pump to the nozzle pathway **242**.

As shown in FIG. 17, the housing **10** may be shaped into a generally flat disc, and thus basically composed of a center frame **100**, a front shell **120**, and a

rear shell **140** all being molded from a dielectric plastic material and assembled together into a unitary structure to form a front compartment **130** and a rear compartment **150** on opposite faces of the frame **100**, respectively behind the front and rear shells. When taking such generally flat disc shape, the front compartment **130** accommodates therein the motor **30**, the battery **50**, and the high voltage generator **40** which are all supported on the frame **100**, while the rear compartment **150** constitutes the concavity **12** for receiving the reservoir **210**. The frame **100** is formed on its front face with individual sections **103**, **104**, and **105** respectively for mounting the motor **30**, the high voltage generator **40**, and the battery **50**, as shown in FIGS. 18 and 19. The motor **30** is received in the section **103** together with a gearbox **31**. The high voltage generator **40** is composed of a transformer **41** and various electric components mounted on a printed board **80**. The transformer **41** is packed into an insulated module fitted in the section **104**. In that the transformer **41** occupies much more space than the motor **30** and battery **50**, the housing is designed to arrange the transformer **41**, the motor **30**, and the battery **50** in compact. That is, the transformer **41** is accommodated within the lower part of the front compartment, while the motor **30** and the battery **50** are accommodated within the upper part of the front compartment in side-by-side relation with each other such that the motor and the battery are arranged in stack with the transformer with respect to a vertical axis of the housing **10**. The section **105** receives, in addition to the battery **50**, a terminal fixture **52** having leads for electrical connection of the battery **50** to the motor **30** and the high voltage generator **40** through a power switch **60** and a control circuit formed on the printed board **80**. As shown in FIG. 20, the gearbox **31** includes a reduction gear set **32** through which the motor output is transmitted

to an actuator **36** provided for detachable driving connection to the joint **238** of the pump **230** on the side of the cartridge **200**. Preferably, the actuator **36** is disposed immediately below a mount **110** formed at the upper end of the frame **100** and is accessible through an opening **112** in the mount **110**, as shown in FIGS. 22 and 23. The mount **110** is somewhat recessed for retaining the dispensing unit **220** thereon when the cartridge **200** is attached to the housing **10**. The mount **110** is cooperative with adjacent side walls **114** to define a positioning means for the cartridge. Preferably, a pair of hooks **108** is attached on the opposite sides of the frame **100** to constitute a positioning means for detachably holding the inner cover **20** on the housing **10**. The hook **108** has a release button **109** which releases the inner cover **20** upon being pressed. As seen in FIGS. 1 and 5, the inner cover **20** may have a flat top **21** formed with a center window **22** through which the nozzle **240** projects when the inner cover **20** is placed over the top half of the housing **10** with the cartridge **200** attached to the housing **10**. The periphery of the window **22** constitutes a retainer ring that holds the flat nozzle bottom **241** on the mount **110** at the upper end of the housing **10**. As shown in FIG. 21, the front shell **120** is formed with a window **122** which communicates with the section **105** for replacement of the battery **50**. Thus, the battery **50** can be easily replaced by simply removing the inner cover **20** as well as a lid **124** of the window **122**. The lid **124** may be eliminated from the device for simplicity.

The rear compartment **150** may be accommodated with a field electrode which surrounds the reservoir **210** to give the same electrical potential to the liquid composition within the reservoir **210** and to the liquid composition within the dispensing unit **220** for keeping the entire liquid composition free from seeing the

electric current which may deteriorate the liquid composition. Such deterioration is particularly seen in emulsion compositions and compositions having particles dispersed therein.

As best shown in FIGS. 23 and 24, in one embodiment, the field electrode **170** is composed of a first plate **171** and a second plate **172** both made of an electrically conductive metal and shaped to define therebetween the concavity **12** surrounding the entire area of the reservoir **210**. The plates **171** and **172** are electrically connected to each other at their peripheries, and are secured to the frame **100** and the rear shell **140**. In order to receive the high voltage, the plate **171** is formed to have a lug **174** which extends through the frame **100** for electrical connection with a terminal **44** of the high voltage generator **40**. The plate **171** is also formed with the voltage terminal **176** in the form of a spring catch for detachable connection with the pin **254** of the dispensing unit **220**, as explained hereinabove.

It is noted in this connection that the metal plate **270** and the **250** of the dispensing unit **220** are electrically connected to the field electrode **170** and therefore act as additional field electrode covering the pump. Also, the metal plate **270** is formed with a metal tube **271** which is inserted into the plug **232** to charge the liquid composition within the plug, and therefore acts also as a further field electrode. Thus, the liquid composition is electrically charged along the entire path from the reservoir **210** to the nozzle **240**. Instead of using the metal tube **271**, it is equally possible to provide an extension which extends from at least one of the plates **171** and **172** and projects outwardly from the concavity to cover the plug **232** and the adjacent part of the dispensing unit.

In a preferred embodiment, when the outer cover **26** is fitted over the

housing **10**, as shown in FIGS. 25 and 26, a sealing rubber **27** at the inner upper end of the outer cover **26** comes into contact with the nozzle **240**. The outer cover **26** is also formed with tabs **28** one of which conceals therebehind the power switch **60** to keep the device inoperative. Also, the outer cover **26** conceals the release buttons **109** therebehind to prevent accidental detachment of the inner cover from the housing **10**.

With reference to FIGS. 27 to 29, the cartridge **200** is again explained in details with respect to geometrical configuration of the reservoir **210**. One preferred embodiment of the reservoir as shown as **210** is made from a deformable plastic material into a flat bag which has a planar configuration of a segment of an approximate circle and has a mouth to which the fitment **212** is attached. The fitment **212** is molded from a plastic material to have a socket **214** for removably receiving the plug **232** of the dispensing unit **220**. In detail, the reservoir **210** is shaped into the segment of circle defined between a chord and a circumference of an approximate circle greater than a circumference of a semicircle. The mouth or the fitment **212** is located at a center of the chord such that the distance from the mouth to any point of the circumference of the circle can be made approximately the same, providing smooth sucking up of the liquid composition from the reservoir and deforming according to the amount of liquid composition left in the reservoir, such that residue left in the end can be kept to a minimum.

Referring to FIG. 30, the power switch **60** preferably includes a switch knob **61** and a switch contact **62** disposed within a center cavity **126**. The switch knob **61** is held within the cavity **126** by means of a retainer ring **127** to be capable of being depressed against a spring bias, and energizes the motor **30**

and the high voltage generator **40** upon being depressed. A light-emitting-diode (LED) **63** disposed in the cavity **126** is energized in response to the knob **61** being depressed to issue a light through a transparent cover **64** for indication of the operation. In a preferred embodiment, the device also includes a selector **70** for selecting one of three modes, i.e., a lock mode for disabling the operation, a spraying mode for enabling the liquid composition to be electrostatically sprayed, and a dripping mode for enabling the liquid composition to be dispensed out of the nozzle without being electrostatically charged. The selector **70** includes a handle **71** which is rotatable around the ring **127** for selecting one of three positions, i.e., a lock position, a spraying position, and a dripping position, as shown in FIGS. 31A to 31C, respectively defining the above lock mode, the spraying mode, and the dripping mode. In the lock position of FIG. 31A, the handle **71** has its portion engaged with the switch knob **61** to prohibit it from being pressed, thereby disabling the operating of the pump as well as the high voltage generator. The selector **70** also includes tact switches **72** and **73** which are arranged on the printed board **80** to be actuated selectively depending upon the position of the handle **71**. In the spraying mode of FIG. 31B, the tact switch **72** is activated such that the pump **230** and the high voltage generator **40** are simultaneously activated upon the switch knob **61** being pressed. In the dripping mode of FIG. 31C, the tact switch **73** is activated such that only the pump **230** is activated upon the switch knob **61** being pressed. Although not clearly seen in the figures, the device may further include an indicator showing which one of the dripping and spraying modes is selected for easy confirmation by the user. Such indicator is preferred to be disposed around the selector handle **71**.

The above operation will be explained also with reference to FIGS. 32 and 33. When the tact switch **72** is turned on by the selector handle **71**, the pressing of the knob **61** energizes a voltage source **81**, a motor controller **82** and at the same time an oscillator **83** for the transformer **41**, thereby activating the motor **30** to operate the pump **230**, while applying the high voltage to charge the liquid composition. When, on the other hand, the tact switch **73** is turned on by the selector handle **71**, the pressing of the knob **61** energizes the voltage source **81** and the motor controller **82** only for operating the pump without applying the high voltage to the liquid composition. Thus, the user can easily drip the liquid composition by simply manipulating the selector prior to initiating the electrostatic spraying, assuring enhanced convenience of handling the device. The voltage source **81**, the motor controller **82**, and the oscillator **83** are formed on the printed board **80**. Further, the device includes an indicator for indicating which one of the spraying mode and dripping mode is activated. The indicator includes an LED controller **84**, an LED oscillator **85**, and a LED **86**. When the spraying mode is selected at the selector **70**, the LED controller **84** acts to turn on the LED **86**, as shown in FIG. 32, in response to the knob **61** being pressed. When, on the other hand, the dripping mode is selected at the selector **70**, the LED controller **84** drives the LED oscillator **85** to turn on and off the LED **86** intermittently, as shown in FIG. 33, in response to the knob **61** being pressed, thereby providing different visual confirmation to the user for easy distinction between the spraying mode and the dripping mode.

FIGS. 34 and 35 illustrate an alternative indicator using a first LED **87** and a second LED **88** that emit different colors. The first LED **87** is alone turned on by the LED controller **84** when the spraying mode is selected, while only the

second LED **88** is alone turned on when the dripping mode is selected.

FIG. 36 illustrates a further modification of the indicator using a buzzer **90** and a buzzer controller **91**. The buzzer controller **91** is included to shift the sound frequency issued from the buzzer **90** or simply turn on and off the buzzer **90**. When the spraying mode is selected, the buzzer controller **91** causes the buzzer **90** to issue the sound of a first frequency or turn off the buzzer **90**. When the dripping mode is selected, the buzzer controller **91** causes the buzzer **90** to issue the sound of a second frequency or turn on the buzzer **90**.

FIGS. 37A to 37C illustrate another scheme of selecting the dripping mode and the spraying mode. In this modification, a tact switch **74** of press-responsive type is cooperative with the switch knob **61A** to constitute the power switch added with the function of the selector. That is, the tact switch **74** gives three positions, i.e., an off position of FIG. 37A, a spray mode position of FIG. 37B, and a drip mode position of FIG. 37C. In the off position, the switch **74** is not actuated to disable the operation of the pump as well as the high voltage generator. When the knob **61A** is pressed to a small extent to correspondingly depress the switch **74**, the spraying mode is selected to energize the pump **230** as well as the high voltage generator **40** for making the electrostatic spraying of the liquid composition. Upon the knob **61A** being pressed to a further extent, the switch **74** is correspondingly depressed to select the dripping mode to activate only the pump **230** for dispensing the liquid composition without the electric charge. Thus, the user can easily select the mode by simply varying the pressure applied to the switch knob **61A**. Alternatively, the dripping mode and the spraying mode may be assigned respectively to the depression of the small extent and to that of the further extent.

FIG. 38 illustrates an electric circuitry incorporated in the device of another preferred embodiment for successfully operating the device in the spraying mode. The circuitry is specifically designed to make the spraying mode successfully and safely. One scheme realized in the circuit is to supply the liquid composition from reservoir **210** to the emitter electrode **250** only after the emitter electrode receives a stabilized high output voltage for successfully charging and spraying the liquid composition. Without being bound by theory, sufficient charging of the area around the emitter electrode prior to spraying is believed to provide good spray quality of the liquid composition at initial usage, as well as usage after the liquid composition is consumed to a certain degree. At initial usage, the liquid composition is delivered to the dispensing unit uncharged. It is believed that advanced charging of the area around the emitter electrode provides sufficient and uniform charge to the liquid composition when delivered to the vicinity for the first time, thereby resulting in a good spray quality. At usage after the liquid composition is consumed to a certain degree, and therefore after the bulk of the liquid composition has gone through a series of charging and de-charging, the liquid composition has a tendency to separate and/or generate clumps of solid material. It is believed that, by charging the liquid composition, such separation and clumps are alleviated, thereby providing a liquid composition in the initially intended physicochemical state. The other scheme is to cease the spraying operation when the emitter electrode receives unduly high voltage that may cause an unallowable corona discharging around the emitter electrode and fail to continue the intended electrostatic spraying. Like parts are designated by like reference numerals utilized in the previous embodiment and no duplicate explanation is made for the respective parts.

In order to accomplish the former scheme, the motor controller **82** is configured to include a delay unit **182** which activates the motor **30**, i.e., the pump **230** only after a delay of about one second from the time when the high voltage generator generates the stabilized high voltage output. In that the high voltage generator, combination of the oscillator **83** and the transformer **41**, is expected to give the stabilized output after an elapse of about few tenths of one second from the time it is energized, the pump is delayed by about one second such that the liquid composition is supplied only after the emitter electrode receives the stabilized voltage output from the transformer **41**. The delay unit **182** is composed of a time which starts counting upon being supplied with the power from the voltage source **81** and triggers the motor controller **82** to activate the pump **230**. Alternatively, the delay unit **182** may be realized by a delay circuit composed of a resistor and a capacitor.

For accomplishing the latter scheme, the circuitry includes an output monitor **45** for monitoring the voltage output from the transformer **41**. The oscillator **83** of the high voltage generator may, for some unpredictable reasons, generate excessively high voltage output from the transformer **41** that causes unacceptable corona discharging around the emitter electrode. In order to eliminate such unacceptable event and to keep the safe operation of the device, the output monitor **45** compares the monitored voltage with a critical level so as to cease activating the oscillator **83** as well as the motor controller **82** when the monitored voltage exceeds the critical level. Thus, the emitter electrode **250** is kept free from the excessively high voltage and therefore from causing the unallowable corona discharging, while the pump **230** or the dispensing unit **220** is disabled to take no superfluous liquid composition from the reservoir **210**. The

voltage output from the transformer **41** is divided by a voltage divider of resistors **46** and **47** to give a divided voltage to the output monitor **45** as representative of the voltage output.

All documents cited in the Detailed Description of the Invention are, in relevant part, incorporated herein by reference; the citation of any document is not to be construed as an admission that it is prior art with respect to the present invention.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.